AMSAT

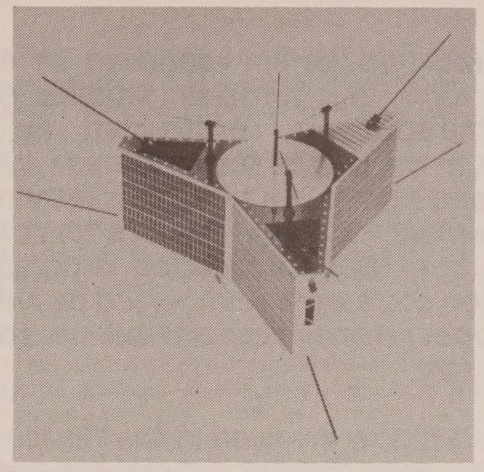
Radio Amateur Satellite Corp.

P. O. Box 27, Washington, DC 20044

Telephone: 301-589-6062

Dr. Thomas A. Clark, W3IWI

President



What is AMSAT?

The Radio Amateur Satellite Corporation (AMSAT) is a non-profit, tax-exempt 501 (c) (3) scientific corporation founded in the greater Washington, D.C. area in early 1969. AMSAT's purposes and objectives, as set forth in the Bylaws are:

A) To provide satellites that can be used for amateur radio communication and experimentation by suitably equipped amateur radio stations throughout the world on a non-discriminatory basis.

B) To encourage development of skills and the advancement of specialized knowledge in the art and practice of amateur radio communications and space science.

C) To foster international goodwill and cooperation through joint experimentation and study, and through the wide participation in these activiites on a noncommercial basis by radio amateurs of the world.

D) To facilitate communications by means of amateur satellites in times of emergency.

E) To encourage the more effective and expanded use of the higher frequency amateur bands.

F) To disseminate scientific, technical and operational information derived from such communications and experimentation, and to encourage publication of such information in treatises, theses, trade publications, technical journals or other public media.

AMSAT is a membership organization open to all radio amateurs and interested non-amateurs. AMSAT encourages the participation of all interested individuals in its activities regardless of membership, and invites licensed amateur radio operators of all countries to engage in communications through AMSAT's OSCAR satellites.

AMSAT's operating funds are derived largely from donations, membership dues and grants from such organizations as the American Radio Relay League (ARRL), the ARRL Foundation, and the International Amateur Radio Union (IARU). Originally spacecraft construction and associated program management was centered in the Washington, D.C. area; however, now affiliate AMSAT organizations around the world share in these activities.

Since its creation in 1969, AMSAT has been responsible for several highly successful satellite projects involving over 5,000 satellite users in more than 100 countries and all 50 U.S. states. These include:

- Australis-OSCAR 5 - a satellite built by students at Melbourne University in Australia. Launched by NASA in January 1970, AMSAT completed extensive modifications, testing, launch arrangements, licensing, and data collection for this satellite project.

- AMSAT-OSCAR 6 - First of a series of long-lifetime operational amateur satellites, AMSAT-OSCAR 6 served for regular amateur use for nearly five years following its launch by NASA in 1972. AMSAT was responsible for the spacecraft design, fabrication, testing, launch arrangements, licensing, and operation. The spacecraft was used for several unique experiments, such as tests to determine the positions of emergency locator transmissions from downed aircraft.

- AMSAT-OSCAR 7 - This amateur communications satellite was launched by NASA in November 1974. Still operational, AMSAT-OSCAR 7's subsystems were developed by amateur groups in the United States, Australia, Canada and West Germany under AMSAT's management. The spacecraft's capability and sophistication are comparable to the first six OSCAR satellites combined.

- AMSAT-OSCAR 8 - Launched by NASA in March 1978, this amateur satellite contains two transponders constructed by AMSAT groups in the United States, Canada, West Germany and Japan. The satellite is intended as a replacement for AMSAT-OSCAR 6 for continued use in the OSCAR education program. Construction costs were reimbursed by ARRL, who has operations responsibility for this spacecraft.

AMSAT is now involved in the "Phase III" project, the development of long-life spacecraft and instruments intended for geostationary, near-synchronous or high-altitude elliptical orbits. AMSAT Phase III spacecraft offer the significant operational advantage over the previous low-orbiting OSCAR's of providing improved coverage for hours at a time over transcontinental distances. This is expected to provide a new communications resource for emergency communications applications and make possible experiments not feasible with lower-orbiting satellites.

AMSAT is also involved in a joint project with its affiliate in England and the University of Surrey to develop an amateur scientific satellite. The "UoSAT" spacecraft, to be launched in 1981, is intended to greatly strengthen the OSCAR education program by providing a number of experiments and instruments that can be used directly in the classroom. In addition, it will provide radio amateurs with new tools for understanding the earth's ionosphere.

In addition, AMSAT has assumed an active role in such activiites as:

A) Assisting in preparation of the U.S. position for the 1971 ITU World Administrative Radio Conference on Space Communications, and advising the International Amateur Radio Union's delegation at the Conference. AMSAT was also directly involved in preparations for the 1979 ITU World Administrative Radio Conference.

B) Preparing documentation on Amateur Radio satellites for the ITU International Radio Consultative Committee (CCIR), the U.S. State Department, NASA, and the Federal Communications Commission.

C) Arranging and presenting papers for numerous technical, professional and amateur meetings.

D) Reviewing and advising on curriculum material on the use of amateur satellite terminals in schools for instruction in the physical sciences.

E) Participating in the program planning activities of the Amateur Satellite Service Council established by the ARRL.

AMSAT's Phase III Program

AMSAT-Phase III is a new series of Amateur Radio communications satellites designed for long-lifetime operation in high-altitude synchronous, circular or elliptical orbits. Phase I of the amateur satellite programs was represented by OSCAR's 1 through 5. These were short-lifetime satellites which served to familiarize radio amateurs with satellite tracking techniques. Of the Phase II series of satellites AMSAT-OSCAR 7 and 8 are still in operation. They marked the development, for the first time, of long-life satellites for two-way amateur radio communications and experimentation. Phase II spacecraft have been designed for fairly low orbital altitudes, below 1,000 miles. These satellites have been used by amateurs in over 100 countries to make hundreds of thousands of contacts. Communication distances have been limited, because of the low altitude, to 5,000 miles and to communications periods of 25 minutes at a time.

The new Phase III spacecraft, now being developed, will provide radio amateurs with a spectacular new communications resource. In the area of public service, Phase III satellites will permit:

- Dramatically expanded emergency communications capabilities, of vital importance for disaster relief operations.
- Transmission of educational material directly to school rooms, using simple receiving terminals.
- New means of low-cost experimentation in satellite techniques, available to all countries alike. There will be no user charges.

UOSAT—the AMSAT scientific and educational amateur spacecraft

by M. SWEETING, BSc, PhD, FBIS, G3YJO*

Introduction

The amateur satellite programme, born in 1961, has witnessed a total of 10 amateur spacecraft launched into earth orbit—of which five may be considered experimental (Phase 1) and five developmental (Phase 2). The first amateur spacecraft to be considered fully operational emerged from the AMSAT Phase 3 programme early last year; however, a failure of the European Ariane launch vehicle has delayed the realization of this operational stage until, probably, mid-1982.

The early experimental satellites (Oscars 1 to 5) were managed by Project Oscar Inc (USA), while the development satellites Oscars 6, 7 and 8 were constructed under the auspices of the Radio Amateur Satellite Corporation—AMSAT, based around Washington DC. Two further development spacecraft have been launched successfully by the USSR (RS 1 and 2).

Although the amateur satellite programme has reflected a substantial educational flavour, the emphasis during Phases 2 and 3 has been on producing amateur communications satellites primarily intended for increasing vhf and uhf communication range between amateur radio operators. Amateur radio is very much a self-learning and training activity even in its simplest manifestation and, as with other amateur off-shoots of professional activities (such as amateur astronomy), has by its peculiar resources contributed much to the overall understanding of its field. In recent years amateur radio has perhaps developed stronger communication skills at the expense of experimental skills, largely due to the impact of relatively cheap, mass-produced, high-technology equipment, and has in turn limited its appeal away from the broader audience of amateur scientists, technicians and dabblers who could so enrich the fraternity.

In an attempt to redress this imbalance, AMSAT-UK is constructing an amateur scientific and educational spacecraft (UOSAT) specifically aimed at generating interest among a wide range of imaginative individuals in an important but now largely neglected aspect of amateur radio.

UOSAT is being constructed at the University of Surrey (UK) and is supported by AMSAT, RSGB, British industry and research organizations.

Mission objectives

The mission objectives may be summarized as follows:

1. To provide radio amateurs with a readily available tool for the study of the propagating medium through which they communicate from hf to microwave frequencies.

2. To stimulate a greater degree of interest in space sciences among schools, colleges and universities by active participation.

3. To broaden the scope of the amateur satellite programme and to encourage the interests of amateur scientists.

4. To establish an active body in the UK with the necessary resources to contribute flight hardware to the amateur satellite programme.

5. To study and evaluate the suitability of novel methods and new frequencies for use in subsequent amateur spacecraft.

Spacecraft systems

The spacecraft systems may be considered as three components—service modules, experiment modules and the mechanical structure.

The service modules comprise all the functions fundamental to the basic operation of the spacecraft, such as the power sources, power conditioning, telemetry system, telecommand system, the general data beacon and the engineering data beacon.

Power source

Four body-mounted solar array panels will each provide 27W dc when fully illuminated. The average power available from the arrays per orbit will be approximately 17W dc, allowing for sun angle and eclipse.

Battery charge regulator and power conditioning module

The bcr regulates the solar array power supplied to the 6Ah 14V dc nicad battery pack with an efficiency around 90 per cent. The pcm delivers regulated power supplies at +10V, −10V and +5V for the spacecraft's electronic systems with an overall efficiency of around 87 per cent.

The average power available to the spacecraft electronic systems per orbit is around 11·5W dc.

General data beacon

A 450mW beacon operating on 145·825MHz will provide the prime interface from the spacecraft to the outside world. This beacon has been specifically designed to provide a healthy satellite-to-ground transmission link, enabling reliable reception by the simplest of amateur ground stations. The modulation form will be nbfm and, in order to minimize doppler tracking, data will be transmitted by afsk. The transmissions will be compatible with standard, unmodified, amateur nbfm receivers, and only a small, fixed, crossed-dipole antenna should suffice for all but the lowest-elevation orbits. A low-cost audio data demodulator will be required to interface with the printer/display, details of which will be published. The beacon will also be modulated by speech from the synthesized speech telemetry experiment and data from the earth-pointing camera.

The data sources available to this beacon are: 1,200 baud ASCII telemetry; 300 baud ASCII telemetry; 110 baud ASCII telemetry; 45·5 baud rtty telemetry; 12/20wpm morse code telemetry; synthesized speech telemetry; spacecraft computer asynchronous interface; and earth imaging system data.

Engineering data beacon

A 400mW beacon operating on 435·025MHz is the primary spacecraft engineering data and high speed experimental data channel intended for advanced amateur ground stations, advanced scientific experimenters and the ground command station network. The modulation form will be biphase psk with the following data sources available: 1,200 baud ASCII telemetry; 300 baud ASCII telemetry; 110 baud ASCII telemetry; 45·5 baud ASCII telemetry; spacecraft computer synchronous interface; spacecraft computer asynchronous interface; spacecraft computer output port; earth imaging system data; direct magnetometer data; and direct radiation counter data.

Telecommand system

Direct and positive control over the spacecraft's on-board systems is essential for efficient mission management and to minimize potential interference both within the spacecraft and to external services. The complexity of the spacecraft and its operating modes are such that manual real-time control alone would present an irksome chore for telecommand station operators, and necessitate a comprehensive network of stations for maintaining day-to-day schedules. Two modes of control over the spacecraft are therefore available;

1. Direct, real-time control by the ground station network for: unscheduled command status changes; command status initialization; loading initial and modified software into the on-board microcomputer; positive control of the spacecraft when in a partial failure mode; and simple command changes.

2. Indirect, stored-program control of the spacecraft executed by an on-board microcomputer upon predetermined schedules or telemetry performance analysis, for: day-to-day scheduled operation; spacecraft mode changes out of range of ground telecommand stations; and surveillance of on-board telemetry and executive control in event of spacecraft emergency.

Positive control over the spacecraft is assured by allowing over-riding precedence to control data emanating from direct ground telecommand. This includes total shut-down of the on-board microcomputer.

The spacecraft computer will employ the same command decoding and distribution system as the direct command mechanism and will behave as a

*Dept of Electronic Engineering, University of Surrey, Guildford, Surrey GU2 5XH.

Reprinted by permission from the Radio Society of Great Britain.

local "ghost" telecommand station feeding scheduled commands into the command decoder according to a programmed "diary".

Telemetry system

Knowledge of the status and performance of the spacecraft systems is similarly essential for efficient mission management and to ensure longevity of the spacecraft's operation. Sensors located around the spacecraft will monitor parameters such as temperature, voltage and current, which are then encoded and made available, in addition to various other processed data, to a downlink beacon via a telemetry module. The basic philosophy of the telemetry system is to provide both a comprehensive surveillance of the on-board systems for engineering purposes and a wide selection of data formats to cater for differing ground station facilities.

Telemetry will be available at the following data rates:

1,200 baud ASCII 600 baud ASCII 300 baud ASCII 110 baud ASCII	asynchronous, seven-bit code
45·5 baud rtty	asynchronous, five-bit code
12/20 wpm cw (morse)	
Synthesized voice	

Any combination pair may be transmitted by the two data beacons upon command.

The telemetry frame comprises 60 uniquely addressed analogue channels with 40 status flags and an identifier. The analogue channels have a range from 000 to 999 thus giving a maximum data resolution of 0·1 per cent. At the highest data rate (1,200 baud) each telemetry frame takes some 8s to be transmitted, which is somewhat less frequent than the experimental instrument sample rate, thus instrument data is time-averaged and presented within the telemetry frame. (High time-resolution experimental data is available via the spacecraft computer for more detailed analysis.)

The telemetry frame format will be as follows:

AMSAT	00000	00000	00000	00000	00000	00000	00000	00000	00000
AMSAT	00000	00000	00000	00000	00000	00000	00000	00000	00000
00000	01000	02000	03000	04000	05000	06000	07000	08000	09000
10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
20000	21000	22000	23000	24000	25000	26000	27000	28000	29000
30000	31000	32000	33000	34000	35000	36000	37000	38000	39000
40000	41000	42000	43000	44000	45000	46000	47000	48000	49000
50000	51000	52000	53000	54000	55000	56000	57000	58000	59000

In line with the mission objectives, UOSAT will have the following experiment complement:

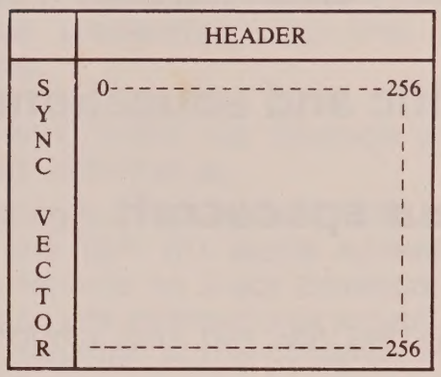
Propagation studies experiments

1. Phase referenced hf beacons on 7·001, 14·001, 21·001 and 28·001MHz, enabling simple aos observation to indicate ionospheric paths or more complex calculations yielding ionospheric electron densities.
2. A three-axis, wide-range, flux-gate magnetometer for the examination of the fine structure of the earth's magnetic field and any disturbances to it and their relationship to radio wave propagation. This data will be available on the general data beacon (145·9MHz) and with higher resolution on the engineering data beacon (435MHz).
3. Two particle radiation detectors and counters (detecting particles with energies >20keV and >60keV) providing real-time information on solar activity and auroral events. This data will be available on the general data beacon (145·9MHz) and with higher resolution on the engineering data beacon (435MHz).
4. Two microwave beacons on 2·4 and 10·47GHz to study shf propagation and the problems associated with inexpensive microwave satellite ground equipment.

Education experiments

1. An earth-pointing, solid-state, charge-coupled-device (ccd) camera will provide land and sea image data for transmission to simple and inexpensive ground stations via the general data beacon (146MHz) using fm synchronous afsk at 1,200 bps—line synchronous. The image format will be presented as a 256 by 256 pixcel digital array with each pixcel having 16 possible digital grey levels. The entire image will be transmitted to the ground in around 3·5min, stored in a solid-state memory and displayed on a domestic television. The ground image area will be approximately 500 by 500km, providing a resolution of some 2km on the earth's surface. The cost of the data demodulator, image memory and display electronics is around £100 and it is anticipated that modules and kits will be made commercially available.

Format:



It may be possible to use this visual display experiment to present processed telemetry and experimental data in a graphical format.
2. Telemetered data from the spacecraft and its experiments will be available at a variety of speeds and formats to cater for a wide range of ground-station complexity.
3. A limited repertoire of telemetry will also be available in synthesized speech for transmission on the general data beacon (145MHz fm) intended for direct reception by the simplest standard nbfm equipment employing no more than a crossed dipole antenna.

Future systems experiments

1. A combination of active and passive attitude control mechanisms based on gravity gradient stabilization and two-axis electromagnetic (magnetorquer) attitude adjustment will be evaluated. The spacecraft is designed to "fly" with the −z facet (bottom) always pointing towards the geocentre. This facet will support the camera and the vhf, uhf and microwave antennas.
2. The 2·4 and 10·47GHz beacons will be used to evaluate the usefulness of these frequencies for future amateur spacecraft in conjunction with relatively simple and inexpensive ground stations.
3. A powerful on-board cmos microcomputer will have access to the s/c experiments, telemetry and command systems enabling: telemetry surveillance; command and status management; experiment data store and processing (eg: image processing, data reduction); orbit data, operational schedules and general news dissemination; and attitude control.

The spacecraft computer is based around the RCA cmos CDP 1802 microprocessor and has direct data links with the magnetometer and radiation detectors experiments. This enables fast sampling of experimental data yielding fine time-resolution structure of these fields. The s/c computer also interfaces directly with the speech synthesizer experiment which can be fed with processed telemetry, experiment data or plain text. Analysis of navigation information from the magnetometer (using it as a coarse sensor) and correlating with an existing model of the earth's magnetic field will allow closed-loop attitude control employing the two-axis magnetorquers.

The spacecraft computer will have access to the telecommand decoder input in parallel with, but on a secondary basis to, the direct ground command receiver. Control data emanating from ground command stations will have priority over locally generated control data at all times, and the s/c computer will have positive shut-down upon ground command in the event of computer malfunction. The s/c computer will be capable of generating the appropriate command repertoire locally as directed by software resident in its memory. This software is loaded from the ground by command stations using the telecommand uplink channel. The entire software library resident in the spacecraft computer can be modified or replaced during flight by ground telecommand stations, in order to accommodate changes in the mission profile and to allow for the rectification of possible software or hardware failures.

Orbit

UOSAT is currently scheduled for launch by NASA into a sun-synchronous, polar, earth orbit in September 1981 as a secondary payload upon a Delta 2310 launch vehicle accompanying the Solar Mesosphere Explorer spacecraft. The programmed orbital elements are as follows:

Altitude: 530km **Period:** 95min
Inclination: 97·5°, sun-synchronous, 3pm descending node.

The expected orbital life-time of the spacecraft at this altitude is around 4·5 years before re-entry. □

The Third Decade of Radio Amateurs in Space

[From Jan./Feb. *ORBIT* Magazine Editorial by G3ZCZ]

Twenty years ago Radio Amateurs thrilled to the announcement of an Orbiting Satellite Carrying Amateur Radio. OSCAR 1 launched on December 12, 1961, with the Discoverer 36 spacecraft, was designed and built by a group of Radio Amateurs in the San Francisco Bay area banded together as Project OSCAR, Inc. OSCAR 1 contained a battery powered beacon transmitter and radiated the Morse greeting, HI, HI on a frequency of 145 MHz until its batteries were exhausted. It weighed about 10 pounds and cost about $65.00 to build.

OSCAR 1 was the first of the Phase I series of spacecraft that demonstrated that Radio Amateurs could design and build working communications satellites. In the first decade Radio Amateurs put into operation the world's first multiple free-access communications satellite (OSCAR 3) and made the first direct satellite contacts between the USSR and the USA (via OSCAR 4).

The Radio Amateur Satellite Corporation (AMSAT) brought the Amateur Satellite Service into its second decade. Founded in 1969 in the Washington, DC area, AMSAT's first task was to put into orbit a satellite designed and built at Melbourne University in Australia. This spacecraft, the last of the Phase I series, known to history as AUSTRALIS-OSCAR 5, was the first Amateur built spacecraft capable of responding to ground commands. The AMSAT Phase II satellite program provided and continues to provide long life communications satellites in low-polar orbits. AMSAT-OSCAR's 6, 7 and 8 enabled many Radio Amateurs to expand their vhf/uhf horizons and affords a glimpse of the capability of an operational Radio Amateur Satellite Communications Network.

During the latter half of the second decade, planning and construction of a Phase III communications satellite was completed. The objectives of the Phase III program are to launch the operational era of the Amateur Satellite Service by providing global satellite coverage to at least 90 percent of the world's Radio Amateurs for many hours each day using just one spacecraft.

As we all know, the Phase III era was stillborn on May 23, 1980 when the Amateur Satellite Service suffered its first loss as the Ariane L02 rocket exploded seconds after leaving the pad. Phase III however still has a date with destiny as ESA has agreed to carry the Phase IIIB spacecraft aboard the Ariane L7 flight presently scheduled for February 24, 1982. This satellite, while being the first to show Radio Amateurs the capability of an operational worldwide communications satellite, is still far from the ideal of providing global coverage to everybody for 24 hours a day, and thus even though Phase IIIB is yet to fly, it is now time to start thinking about Phase IV.

Phase IV could provide global coverage to everybody 24 hours a day if the single satellite requirement is changed. If SYNCART packages are placed on three host space platforms in geosynchronous orbit, any Radio Amateur within line of sight of such a platform would be able to work anyone else who also is able to see the same platform. Each platform can see (and thus work) one third of the globe. Any lucky Radio Amateur able to see two such SYNCART's would be able to work two thirds of the globe directly. Consider for example three platforms located in geosychronous orbits above longitudes 75°E (Indian Ocean), 200°E (Pacific Ocean) and 330°E (Atlantic Ocean) (See Fig. 1 on page 6 of ORBIT Magazine Number 1). With such a system, Europe and most of Africa can work both the Atlantic and Indian Ocean SYNCART's, Japan can work the Indian and Pacific Ocean ones while much of the USA can work both the Pacific and Atlantic Payloads. This scheme gives everybody communications capability over at least one third of the world, possibly more for 24 hours a day with 100 percent reliability. A quick glance at the world map shows that if these SYNCART packages are interlinked, full global coverage is provided to each and every Radio Amateur using at the most one interlink. Thus India could work California by means of the Indian-Pacific SYNCART link. That same station in India would talk to New York via the Indian-Atlantic SYNCART link. The interlink capability would be provided by a ground transponder that would be situated in a location that can see two platforms at the same time. The actual location of the ground segment of the communications link will of course depend on the locations of the SYNCART's (space segment) and that will depend on the host platform.

As the required bandwidth is not available below 435 MHz, Phase IV will probably carry a Mode M transponder initially. The uplink will be about 1269 MHz, the downlink at 436 MHz. Each SYNCART will contain the equivalent of three Phase III passbands separated by, and associated with guard band areas. At the center of the space segment is a passband designated for in-zone working. This passband is used by any station within range of a SYNCART to work any other one within range of the same SYNCART. At the low frequency end of the central passband is another passband designated for interlinking to the west. This passband would be used by a station for a double hop QSO with stations not in his own zone, but in range of the SYNCART located to his west. A similar passband is available at the high-frequency end for double hop contacts with stations using the SYNCART to his east. Thus India would work New York via a double hop or space-earth-space segment link in the low passband, would work Europe via the single hop space segment (in zone) center passband and would work California via the double-hop high passband. The ssb/cw band plan for the occupancy of each subband would be identical and be based on the AMSAT band plan or percentage technique originally proposed by G3IOR and G3ZCZ for use with AMSAT-OSCAR 7 and later modified for Phase III. Since each SYNCART would provide effectively the same band of frequencies, the band plan would be the same worldwide. The ground segment would be an official AMSAT transponder station that would receive the interzone downlinks and transpose them to the relevant uplinks. This ground station would receive the West downlink of one SYNCART and reradiate it to the East uplink of the other, while transponding the East downlink of the second SYNCART to the West uplink of the first. Since the band plan is global, the ground segment stations can be identical reverse Mode M transponders.

Communicating through Phase III will be simpler than through Phase II, even though the downlink is expected to be 1½ S units weaker than that of the AMSAT-OSCAR 7 Mode B transponder and the uplink may require up to about 10 dB more transmitting power. Communicating through Phase IV is going to be even simpler, because the transponder will be available 24 hours a day and no tracking will be required.

The implementation of a Phase IV Radio Amateur Satellite Communications Network in no way precludes the Amateur Satellite Service from continuing to build and launch Phase II or Phase III types of spacecraft. That will depend on the constructional and launch capabilities available around the world. The day may yet come when a multiplicity of spacecraft are available in different orbits for various purposes much as the different hf bands are used for different purposes due to their different propagation characteristics.

To the radio amateur, Phase III will provide:

- New amateur bands comparable to the 20-meter band and, yet far more reliable and predictable for two-way communications.
- A means of communicating over transcontinental distances for many hours at a time using relatively low-power amateur terminals and small antennas.
- A highly effective means for transmitting amateur bulletins and training material throughout entire continents.
- Far more efficient use of the vhf and uhf amateur bands, particularly for long-distance communications.

The Phase III-B spacecraft exceeds all previous OSCAR's combined in operational capability and technical sophistication. It will contain a 50-watt communications transponder using the 435 MHz amateur satellite band for its input passband and a 145.9 MHz output. Bandwidth is 150 kHz. The transponder will operate in a linear, multiple-access mode to serve hundreds of users simultaneously. Users will be able to access these satellites with simple, off-the-shelf equipment. The spacecraft's effective radiated power is expected to be 500-1,000 watts, achieved in part through use of directive antennas on the satellite. This high power level will provide typical users with voice signal (ssb) reception at a signal to noise ratio of from 25 to 30 dB.

An onboard microcomputer is expected to greatly enhance the operational flexibility of AMSAT-Phase III. The computer will control housekeeping functions, experiment scheduling, telemetry and telecommand data-handling.

A synchronous Phase III satellite called SYNCART will provide stations over ⅓ of the earth's surface with 24 hr/day communications. In addition to a 100 kHz wide general communications passband SYNCART will have two dedicated subchannels for emergency voice and data communications. A packet switching network is also planned for SYNCART. The SYNCART transponder will have selectable uplinks at 145 MHz and 1260 MHz with a downlink at 435 MHz.

AMSAT-Phase III -- a significant new step forward for the world's growing population of radio amateurs, offering new resources for communications and public service.

Are you an AMSAT member?

YES! I want to be a member of the AMSAT Team and receive *ORBIT* Magazine. Enclosed please find my ☐ Check ☐ Money Order or authorization for ☐ VISA ☐ Master Card.

☐ New ☐ Renewal
☐ $16.00 (North America)
☐ $20.00 (Overseas)
☐ $20.00 (Member societies/clubs)
☐ $_____at the same rates to prepay for _____years.
☐ $200.00 for Life Membership
☐ $_____donation to be applied to the Matching Fund for satellite hardware construction.
☐ $_____donation which I pledge to make

☐ $_____to sponsor solar cells ($10.00 each)

Name_____Call _____

Address _____

City_____State_____Zip _____

Your contributions are tax exempt under U.S. IRS 501c3 since AMSAT is a nonprofit Scientific and Educational organization.

For VISA/Master Card contributions, please complete:
Card No._____Exp. Date_____
Bank Number (MC only)_____
Signature_____

AMSAT, P.O. Box 27,
Washington, DC 20044

10 STEPS TO SUCCESSFUL OSCAR COMMUNICATIONS

Things Even Your Best Friends May Be Afraid to Tell You

"Boy, I called that K1XA for almost the entire Mode A OSCAR 8 pass last night. He kept calling CQ. He sure was loud. Doesn't that guy have a receiver or is it me?"

Sound typical? Perhaps the biggest complaint, and biggest problem in the history of amateur satellite work, is typified by the last comment. For some unexplained reason, hams have invested a lot of time and effort in their transmitting set-ups, but are willing to use almost anything for reception. The frustration dealt out to other hams trying to contact a station who receives poorly is only a small portion of the problem. In their frustration of receiving their own downlink signals poorly or not at all, a lot of hams turn up the EIRP, figuring that will make their downlink signal stronger. It does up to a point. Beyond that point where a downlink signal is louder than the transponder beacon signal, the internal automatic gain control in the satellite transponder reduces the transponder receive sensitivity. Not only does this prevent the offender from getting much louder, it also prevents *all* the other stations in the passband from being heard. The effect is very similar to when your next-door neighbor ham fires up at 7124 kHz while you're listening to 7210 kHz. The whole receiver desenses, and what little you can copy isn't very readable. The situation on the satellite really deteriorates when everyone turns up their power in an attempt to be heard when the satellite desenses.

Is there a solution? There is a very effective remedy, which also happens to be very simple. Unfortunately most hams consider the solution as a moralistic edict, heaped upon them by an unfeeling, ignorant *Big Brother.* The cure: effective receiving set-ups. Everyone who is able to hear very effectively will find it unnecessary to run excessive power to attain a satisfactory signal-to-noise ratio. The transponder won't desense and everyone will be happy.

"Alright then, wise guy," you're probably saying, "how do I get an *effective* receiving set-up?" Obviously, there is no one simple answer; a lot depends on the individual circumstances. There are a lot of little things that will improve almost every station that doesn't already have first class receiving capabilities. If the satellite beacon is not several dB out of the noise (as much as 15 or 20 dB on an overhead pass), then these suggestions will be of use to you.

1) *Use a different 10-meter receiving antenna.* That tribander at 40 feet may be just the ticket for working DX via the ionosphere, but really is an inferior satellite antenna. Why? The tribander probably has a terrific lobe at 17° above the horizon, but not much elsewhere. The vertical beam width of the tribander and ground reflections combine to produce nulls all through the vertical pattern of the antenna system. This isn't very pronounced when you're working a station via the ionosphere; usually you're aiming at the horizon. Higher angles of radiation are just wasted for long distance ionospheric contacts. But, the satellite only spends a small portion of its orbit actually at your horizon. When the satellite passes through these nulls, it may fade into oblivion.

There are two solutions. The first is to raise your tribander to a height of say 200 feet or so, where the ground reflection interference is minimal and mount the antenna on a fixture such that you can steer it both in azimuth and elevation. For most people that solution is somewhat less than practical. A second solution is to take advantage of the ground reflections rather than avoid them. An antenna with a very broad pattern, such as a horizontal quad loop or a dipole placed 0.375 wavelength (about 12.5 or 3.85 meters) above the ground has a pattern suited for Mode A reception.

2) *Add a 10-meter preamp.* Many receivers destined for the ham-bands are optimized for the most used sectors of the bands. Since 10 meters is so wide, it's very difficult to get good performance at 28.5 MHz and still perform well at 28.0 or worse yet 29.5 MHz. One solution is receiver modification but a better avenue is the use of a low-noise preamplifier. Most receivers are least sensitive on 10 meters, at least compared to the lower bands, so a preamp will be of benefit to almost any receiver. There are commercial units available from a couple of manufacturers and very simple but effective ones are published from time to time in the ham magazines as well as in the *Radio Amateur's Handbook.* For the ultimate, install the preamp at the antenna. A preamplifier combined with the aforementioned antenna may well bring the owner into an entirely new world of satellite communications. One note of caution: If you're using a transceiver for 10-meter reception, be absolutely sure that it's impossible to transmit into the preamp. Otherwise, it's bye-bye preamp.

3) *Use circular polarization on 2 meters and 70 centimeters.* Most of the satellites' antennas are circularly polarized, so you'll gain 3 dB over a linear antenna. More importantly, fading is drastically reduced. On the Phase III satellites, using a linear polarized antenna will most surely be a disappointing experience. Spin modulation, a form of very fast fading, will make the satellite signal sound like it's coming from the whirling blades of a helicopter. The ability to switch circular sense, from left hand to right and vice versa from inside the shack, can also be a valuable asset. Not only do different satellite modes require different senses, but ionospheric effects occasionally favor one sense over the other. Switching polarizations might yield an improvement of as much as 20 dB.

4) *Use a 2-meter preamplifier.* One of the big factors in popularizing 2-meter sideband and cw in the past few years has been the advent and proliferation of commercially made multimode transceivers. Drawing from their experience in designing hf sideband equipment as well as their vhf fm work, the manufacturers have combined the two yielding transceivers with few compromises. One of the compromises does affect satellite users, though. The receiver "front ends" are designed with the best attributes of fm transceivers destined for use in a highly populated area, such as Japan. The receivers are very resistant to overload on the fm channels from both nearby stations and from out-of-band commercial signals. Unfortunately, the noise figure of these transceivers is less than optimum. They have been measured as having noise figures between 5.5 and 10 dB. Add a couple dB of feed line loss to this and your 2-meter downlink capabilities are severely limited. Just as with 10 meters, the solution is to use a preamplifier. Again, the magazines and the *Handbook* offer simple designs and inexpensive units are commercially available. The caveat regarding transmitting into the preamp applies here. The preamp should be connected literally to the transceiver where it is only in the receive line. Some manufacturers have provided an alternative; preamps with built-in switching to automatically bypass themselves on transmit. Mounting the preamp at the antenna will circumvent the feed line's contribution to receive noise figure.

5) *Use a 70-cm preamplifier.* Most converters, commercial and otherwise, are deficient in noise figure. The same principle applies here as on 10 and 2 meters.

6) *Install a band-pass filter at the 435 MHz front end.* A severe problem with operating through the 146 to 435 MHz satellite systems occurs at the ground station. The third harmonic from the 2-meter transmitter can desense the 70-cm receiver. This is partly a technology problem, owing to the difference in semiconductors suitable for use at 435 MHz versus those for use at 146 MHz. Assuming that the transmitter itself doesn't emit excessive third harmonic energy (which would be a violation of the law, incidentally) the solution is to place a filter in the line between the receiver front end and the antenna. Not only will this clear up the desense problem from the transmitter, but it may reduce some of the interference caused by radar and some commercial services. The filter should be low loss so as to not degrade receiver sensitivity. Commercial units are available and a suitable design is shown in the *Handbook.*

7) *Minimize system losses.* As was mentioned earlier, any losses between the receiver front-end and the antenna degrade system performance. Transmission line losses, connector losses, even connection losses all reduce effectiveness. Perhaps the soundest investment a ground station builder can make is in quality, low loss, coaxial line and high quality connectors. Properly installed and weatherproofed, an installation like this should provide years of trouble free and satisfactory service. Make good, clean connections to the antennas (use steel wool), and weatherproof them with RTV silicone rubber or spar varnish. Tape the feed lines to solid tie points to prevent placing undue strain on the cables; also tape up the coaxial connectors. Uhf connectors have no place at 435 MHz; use N type or other constant-impedance connectors. They're also worth using at 146 MHz. Don't use cheap relays; they're false economy.

8) *Use az-el mounts for directive antennas.* Also make sure that you can accurately point the antennas.

9) *Have accurate orbit information.* Whether you are using a plotter, a calculator, a computer print-out or even a computerized system to point your antennas, use the most accurate information you can get. Since the orbits are somewhat dependent on solar influences, don't rely on year-old data. Don't even rely on three-month-old data, especially on Phase II satellites. Being two minutes off in antenna pointing out of an eight-minute pass negates all the work you've done to set up your station.

10) *Use a reliable means for adjusting transmitter output.* As was mentioned, nobody's your friend if you overload the satellite. On most modern sideband rigs, turning the microphone gain up or down is a suitable means to adjust output power. Other means might be necessary when a converted fm rig or other class C type transmitter is used.

USING A PHASE II SATELLITE

The first step in working the satellite is to find out where the satellite is. As the spacecraft is constantly moving, some type of tracking calculator is needed. The simplest type of tracking device is an OSCARLOCATOR, available from ARRL. Briefly, you use one reference point each day, usually the first time in a given (UTC) day that the satellite crosses the equator in a northerly equation. The equator crossing (EQX) time and longitude, when and where the satellite passes over the equator, is available from numerous sources such as W1AW Bulletins and the various amateur publications. With this information, you can easily determine the satellite's approximate location and where to point your antenna at any given time from any point in the Northern Hemisphere.

More-sophisticated calculating techniques are also possible. Actual antenna bearings can be mathematically calculated and recorded for a large number of points during a satellite pass. Programmable calculators and even computers facilitate this approach.

As home computers become more popular, mechanized tracking systems will doubtless become standard, further simplifying the tracking routine. Several hams already use computerized systems, and the heavy involvement of computers in the Phase III project will bring more computers into use in the ham shack.

Regardless of the approach taken, it is a good idea to document your calculations well in advance of the pass. Jot down all the information in a logical fashion on a work sheet that is easy to read. You will have enough to do during a pass, with turning your receiver and transmitter, aiming antennas, logging and actually making contacts, without adding the burden of calculating the orbital data at the same time!

Using your system, whatever it may be, figure out when AOS is for your location and the azimuth (compass heading) to where the satellite will rise. Since the satellite will come into "view" on the horizon, you automatically know that the required antenna elevation at AOS is 0 degrees; in other words the antenna points parallel to the ground. Record on the chart your calculated AOS time, and the associated antenna azimuth and elevation. Now, recalculate the antenna readings for the time one minute after AOS. Record these values on the chart. Continue for every one-minute interval until LOS. If you later find that your antennas are very sharp in beamwidth and require greater pointing accuracy, reduce the interval to 30 seconds.

Using all this information is much simpler than it sounds. At the times indicated on your chart, simply point your antennas in the azimuth and elevation shown. It's that simple. Stick with the chart. Often times satellite users won't have calculated too well, or they figure that they don't need advance planning. Signals start fading or are weak to begin with, so they wildly start rotating their antennas in an attempt to find the satellite. Quite obviously, this is not the most effective approach. Find a tracking system you are comfortable with and plan the pass in advance.

Now that the preliminaries are completed, the actual fun of working through the satellite can begin once it's in range. The best procedure is to have your antennas pointed toward the AOS point and begin listening at the transponder beacon frequency several minutes before you expect acquisition. You'll probably have to tune a little off the published frequency as Doppler shift makes the signal appear higher or lower than expected. If you don't hear the beacon within a minute or so of what your chart predicts, something is wrong. Likely possibilities are miscalculations on your part, inaccurate orbital data, listening to the wrong transponder for that day, equipment failure, or even a miss-set clock. The keynote of satellites is reliability; failure is rare compared with various equipment failures and mistakes encountered on the ground.

Once the satellite is accessed, you can set about the task of making a contact. The toughest part is setting your transmitter frequency so that it is retransmitted on the proper downlink frequency. Calculating the expected downlink frequency for a given uplink frequency will put you fairly close. An alternative is to use a reference chart, which plots output frequency versus input frequency. With either of these methods, Doppler shifts and equipment frequency inaccuracies will only place you close to the correct frequencies, but close enough so that sending a few words of sideband or a few dits will enable you to pinpoint yourself. The key word is few. Unfortunately, you'll often hear a series of dits swishing up and down the passband. Not only is this inconsiderate, it also wastes time, which is in very short supply during a pass. Initially this may seem like an impossible task or one best suited to an octopus. With a little practice, however, the longing for an extra set of hands gradually subsides.

Since you're listening on an entirely different band from that on which you're transmitting, full duplex operation is possible: you hear what you're sending through the satellite as you send it! (Traffic handlers often go to great effort to achieve this.) The ability of the station you're working to interrupt you while you're transmitting greatly improves the natural flow of the contact. It is even common for a CQ to be answered while it's being sent. Once again, anything to save time is to your advantage.

Typical contacts through the satellite are short contest-type exchanges. Exchanging calls, signal reports, locations and names is the extent of most contacts. Time is of the essence: Long-windedness doesn't work. Like an fm repeater, the satellite eventually times out, in this case, by going out of range.

A typical contact might go like this:

CQ CQ CQ DE W1AW W1AW W1 . . .
W1AW DE KIXA 579 CONN BOB
K1XA DE W1AW 569 CONN CHUCK 73
W1AW DE K1JX . . .

There is one other very important aspect for the satellite user to consider. The transponder's internal automatic gain control system reduces the receiver's sensitivity as the signal input level increases. This is done for two reasons. The first is to prevent receiver overload which might produce spurious signals within the transmitter passband. Second and more important, is that theoretically a very loud signal would be retransmitted with as much power as the transponder's transmitter can muster. If this were to occur, serious damage could be sustained by the satellite. Even with the agc system, transmitter current drain rises with very strong input signals, placing unnecessary and undesirable burden on the spacecraft batteries. It is every satellite user's responsibility to ensure that he or she does not transmit too great a signal to the satellite.

The proper transmitter power level is easy to determine. Since the downlink signal you receive indicates the effectiveness of your uplink, adjustments of your uplink power are reflected in the strength of the downlink signal strength. Your downlink strength should be no louder than the transponder beacon. Following this simple rule prevents receiver desense and guarantees easy transponder access for others as well as preventing satellite damage.

The 4 × 3 × 5 MHz Filter

If your 435-MHz receive system is sensitive enough to get desense from your 2-meter uplink, this filter should solve the problem. Most Mode J OSCAR users have experienced some difficulty getting satisfactory use from this mode. Being able to receive well is the secret in satisfactory Mode J operation. Introducing this filter should narrow the passband enough to allow rejection of unwanted noise and birdies. Inserting the filter before any preamp or converter in the antenna feed line should do the trick. It may be necessary to use a similar filter built for 2 meters after your uplink 2-meter rig, if the third harmonic level is high.

Most small plumbing businesses can supply you with the material you will need for the 3/4- and 3-inch copper pipe. A local plumber cut four pieces of 3-inch pipe 5 inches long for $6. The four 3/4-inch pieces, cut, cost $1.25. The only other item of cost is the type of coax receptacle you want to use. Make it adaptable to your system, without sacrificing loss. The filter should be built for about $5.

Care is the name of the game when it comes to soldering the double sided pc board: Direct the heat of your torch at the pipe and enough heat will transfer to the pc board to allow the solder to flow. It is not necessary to use pc board, as copper or brass that is thick enough to support the unit will do. If copper or brass is not available, a soup can that you can solder to works well. But the more stable the structure, the better.

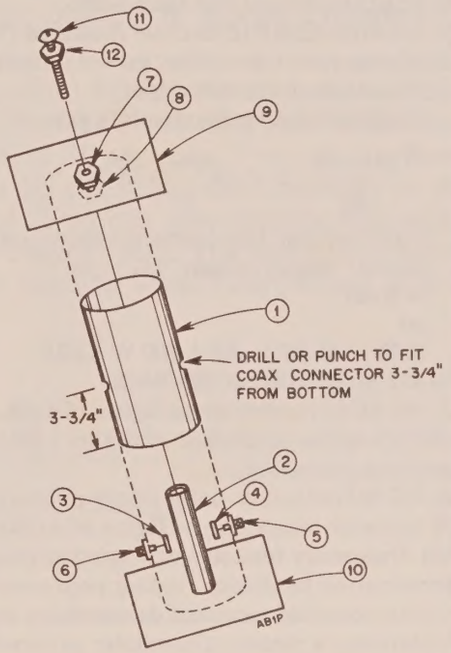
The filter has a narrow passband, but with a good high-gain, low-noise system, you should be able to peak up the noise with no signal. If a signal is needed, a low-power 145.050-MHz signal into a dummy load should give you a test signal to peak the filter.

The insertion loss measured in the ARRL lab was around 0.4 to 0.5 db. If you want to improve this figure, use silver solder and silver plating. This filter was fashioned after a design by Joe Reisert, W1JR, and was built by Jay Rusgrove, whose assistance in this endeavor is appreciated.

Please let us know how this filter works for you or if you have any improvements that will increase its effectiveness. See you on Mode J. Bernie Glassmeyer - W9KDR.

Parts List

Piece No.		
1	Pipe, Copper 3" dia. 5" long	Cut ends square. Drill or punch for connectors 3-3/4" from bottom.
2	Pipe, Copper 3/4" dia. 4" long	Solder to center of 10
3	Disc, Copper 3/4" dia. 1/16" — 1/8" thick	Drill thru center. Solder solid hook up wire between disc and connector to space disc 3/16" from pc 2.
4	Disc, Copper 3/4" dia. 1/16" — 1/8" thick	Drill thru center. Solder solid hook up wire between disc and connector to space disc 3/16" from pc 2.
5	Connector, Coax	BNC, SMA or N type. Solder to prevent turning. For large connector use chassis punch
6	Connector, Coax	BNC, SMA or N type. Solder to prevent turning. For large connector use chassis punch.
7	Nut, Brass 1/4"—20 hex	
8	Nut, Brass 1/4"—20 hex	
9	P/C Board, double sided. Top 4" × 4".	Drill hole in center to clear 1/4-20 bolt Solder 7 and 8 each side of hole. (Use bolt 11 to hold nuts in place when soldering.)
10	P/C Board, double sided. Bottom 4" × 4".	Solder 2 in center.
11	Bolt, Brass 1/4-20 × 3"	Insert thru 12 then thru 7 and 8.
12	Locking Nut, Brass 1/4-20 Hex	To hold piece 11 after resonance adjustment.



STATION REQUIREMENTS FOR SATELLITE COMMUNICATIONS

Most long-distance amateur communications depend on the application of natural phenomena such as ionospheric refraction or tropospheric scattering. Station design to take advantage of these phenomena is largely a matter of personal preference; bigger stations usually mean bigger signals. Operation through a satellite is somewhat different; fixed conditions such as transponder receiver sensitivity, transponder power output and path loss are the dominating factors in establishing minimum ground station requirements. Unlike other areas of amateur interest, having an inadequate station won't merely limit satellite communication effectiveness, but might prohibit success entirely. Technical considerations in station design for satellite operating are more than just personal preference.

Satisfactory satellite communications might be possible with your existing station, but planning your satellite ground station around certain parameters will enhance your effectiveness and enjoyment. The orbit of the Phase III satellites imposes greater demands on a ground station, so if you build your station to the rigors of working through Phase III, only slight adjustments in transmitter output power will be necessary for work through a Phase II satellite.

Here are the parameters you should build your station around, for present and planned satellites.

1) 146-MHz antenna gain of at least 13 dBi (decibels over isotropic), circularly polarized. The polarization should be switchable between left- and right-hand circular. The antenna should be accurately pointable in both azimuth and elevation. More antenna gain is always desirable; when the downlink is on 2 meters, signal strengths are increased with greater gain. When the uplink is on 2 meters, lower transmitter power is necessary to achieve a given effective radiated power. A disadvantage of higher gain antennas is that they have narrower beamwidths and must be aimed more accurately.

2) 435 MHz antenna gain of at least 13 dBi, circularly polarized, again switchable. The very same considerations apply to 435 MHz as just described for 146 MHz.

3) 10-meter antenna gain of 2 dBi. The key factor here is not high gain, but rather effective coverage. Antennas placed above ground (not being in free space) are subject to ground-reflection interference, causing nulls in the vertical pattern of the antenna. Graphical presentations of this effect are shown in the *ARRL Antenna Book*. The best bet here is to use a virtually non-directional antenna placed at a height above ground to take advantage of favorable ground reflections.

4) Feed line loss of less than 2 dB.

5) 146 MHz EIRP (*E*ffective *R*adiated *P*ower over an *I*sotropic source) of 100 watts. Your EIRP can be calculated by multiplying your transmitter power output in watts, by your antenna gain minus feed line loss. Example:

10 watts transmitter output
12 dBi antenna gain (absolute gain = $10^{\frac{\text{gain dB}}{10}}$; $G = 10^{12/10} = 15.85$)
2 dB feed line loss (same as above, but loss is "negative gain"; $G = 10^{-2/10} = 0.63$)
so
10 W × 15.85 × .63 + 100 W EIRP

6) 432 MHz EIRP of 800 Watts.

7) 146 MHz receive noise figure of 4 dB. Any loss between the antenna and the receiver input is directly added to the receiver noise figure (i.e., 2 dB line loss plus 3 dB receiver noise figure equals 5 dB receiver noise figure). Higher noise figures reduce signal to noise ratios.

8) 432 MHz receive noise figure of less than 4 dB.

9) 10-meter receive noise figure of 4 dB or less.

10) Frequency readout resolution at least 5 kHz, on both transmit and receive. 1 kHz readout is better. Accurate frequency determination facilitates finding your own signal through the satellite without causing needless QRM.

11) An accurate means of determining antenna pointing directions at all times during an orbit. This could be in the form of calculations, a plotter, a computer printout or even computer controlled antenna pointing.

Like any other aspect of hamming, trade-offs can be made which will minimize both expenditure of time and money. Up to a point, antenna gain is easier to attain than transmitter power, and a lot cheaper. It's easier to put up a bigger Yagi to increase your EIRP than it is to build or buy an amplifier. The antenna also works on receive, doubling the benefit of your antenna efforts. All things considered it's much more cost effective and desirable from a performance standpoint to optimize the receiving set-up before investing in bigger transmit ware. All too many stations suffer from "alligatorism," (big mouth, little ears): don't be the cause of frustration to others, as well as yourself.

AMSAT NETS AND BULLETINS SCHEDULES

The following AMSAT Nets meet regularly to disseminate information to newcomers and to keep regular satellite users in communication with one another.

USA-East Coast Net	Wednesdays	0100Z	3850 kHz	Net Control WA3NAN
USA-Mid States Net	Wednesdays	0200Z	3850 kHz	Net Control WØCY
USA-West Coast Net	Wednesdays	0300Z	3850 kHz	Net Control W6CG/W6DOW
International Net	Sundays	1800Z	14,280 kHz	Net Control WA3NAN
International Net	Sundays	1900Z	21,280 kHz	Net Control WA3NAN
AMSAT Calling Frequency		24 hours	28,880 kHz	

Bulletins of general interest to those interested in amateur satellites are transmitted regularly on OSCAR-7 and OSCAR-8 reference orbits, at approximately 10 minutes after ascending node. These bulletins, transmitted on a downlink frequency of approximately 29,490 kHz, 145.960 MHz and 435.160 MHz, can be received over most of eastern North America.

THE AMERICAN RADIO RELAY LEAGUE, INC.

ADMINISTRATIVE HEADQUARTERS NEWINGTON, CONNECTICUT, U. S. A. 06111

MONITORING OSCAR'S HEARTBEAT

HI 120 255 . . . . Every twenty seconds OSCAR 8 transmits its heartbeat to amateur radio operators and others throughout the world. This "heartbeat" is the Morse coded telemetry data describing such important functions as the satellite's voltage, current flow, temperature and power output. These data help us on the ground keep close tabs on the health of the OSCAR (Orbiting Satellite Carrying Amateur Radio) as it circles the earth hundreds of miles overhead. OSCAR 6, for example, continued to function for years beyond its expected lifetime, because the telemetry from the satellite allowed amateur ground-based command stations to keep the satellite's temperature and current flow within tolerable limits. You can help this important aspect of amateur satellite operations by copying the telemetry from OSCAR 8 and sending it promptly to ARRL Hq. We'll acknowledge your first such report with a handsome OSCAR 8 QSL card.

To receive the telemetry you will need some radio equipment and orbital information. January and February, 1978, *QST* contain articles on receiving OSCAR 8 and the orbital information is provided daily by W1AW and monthly by *QST*. Listen for the telemetry on the OSCAR 8 Beacon Frequencies: Mode A: 29.400 Mhz; Mode J: 435.095 Mhz.

The OSCAR 8 telemetry is in the form of: HI 1(N) 2(N) 3(N) 4(N) 5(N) 6(N). HI is the satellite identification and N is a two digit number. A sample frame is : HI 120 255 380 451 551 620. These data are sent in Morse Code at about 20 words per minute and repeated every 20 seconds. You can copy and decode the telemetry even if you are unable to copy the Morse Code by recording the telemetry at the highest speed of the recorder, and playing it back at a slower speed. You can also decode this information yourself using the graphs and equations on the opposite side of this sheet. The information you obtain from the satellite telemetry is like a doctor's EKG, so keep in tune to what's happening now in the "Heartbeat" of OSCAR 8.

DATE (UTC) _____ MODE A J

TIME (UTC)	ORBIT #	1(N)	2(N)	3(N)	4(N)	5(N)	6(N)	Comments: (RST, calls heard, etc.)

Save this sheet for your future reference but please follow the above format when submitting the data you've copied.

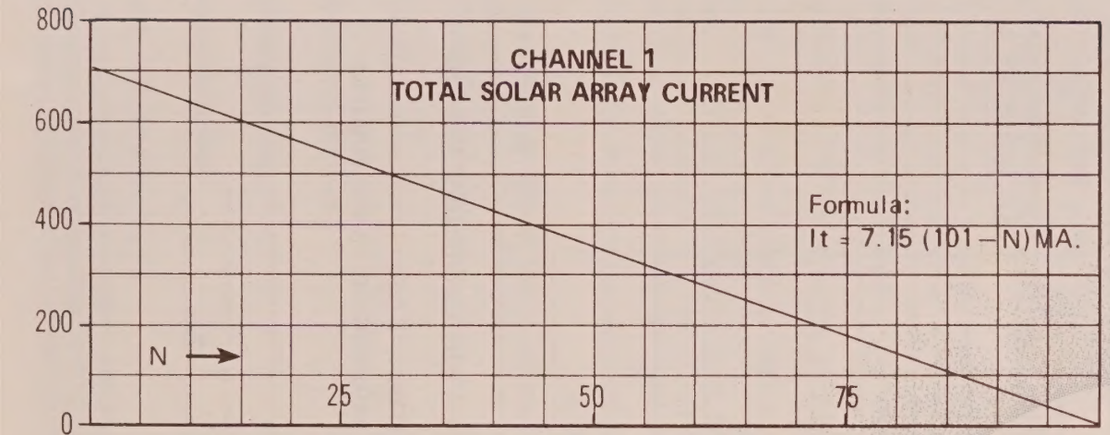
RETURN PROMPTLY TO: ARRL HQ., 225 MAIN STREET, NEWINGTON, CT 06111

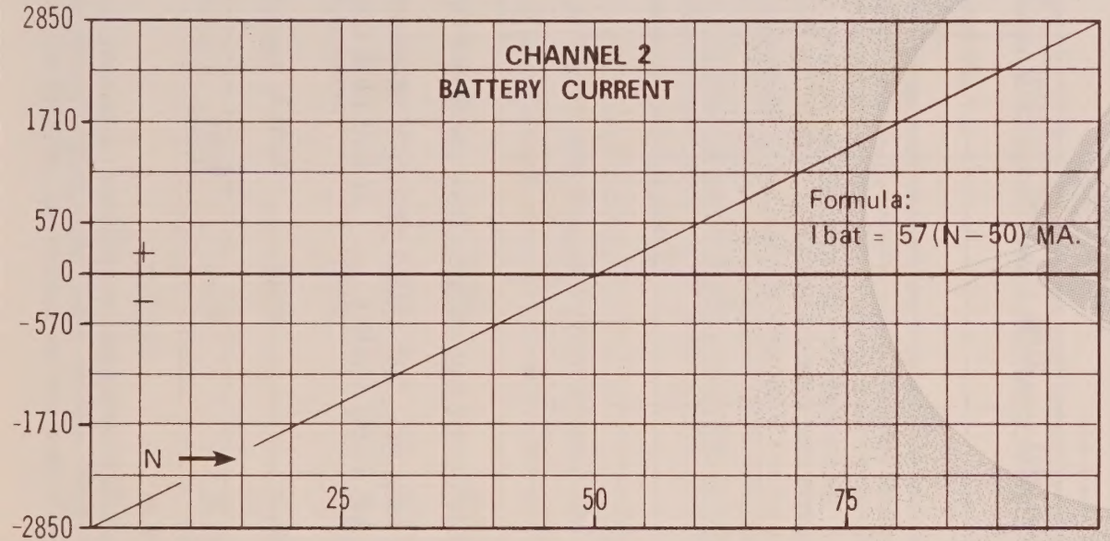
Please send an SASE for: OSCAR 8 QSL CARD ____, or any additional information on the amateur satellite program ____.

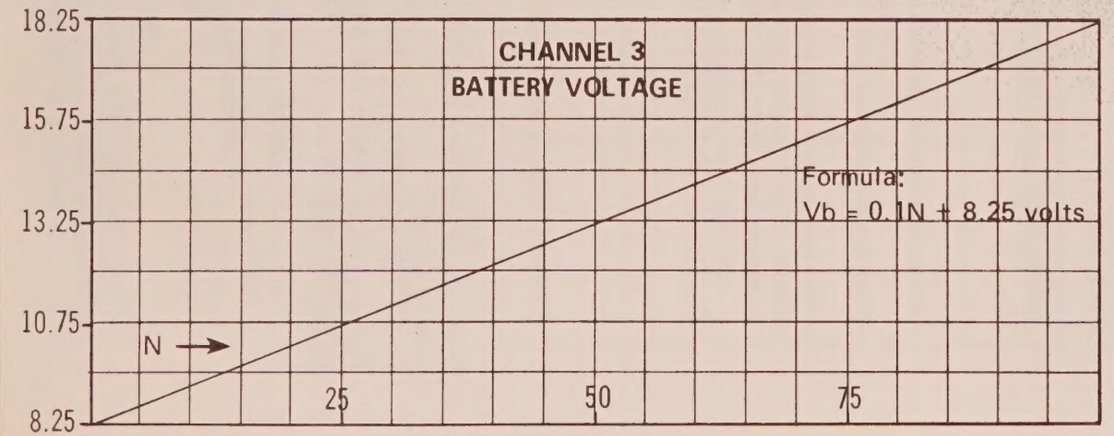
NAME _____ CALL _____

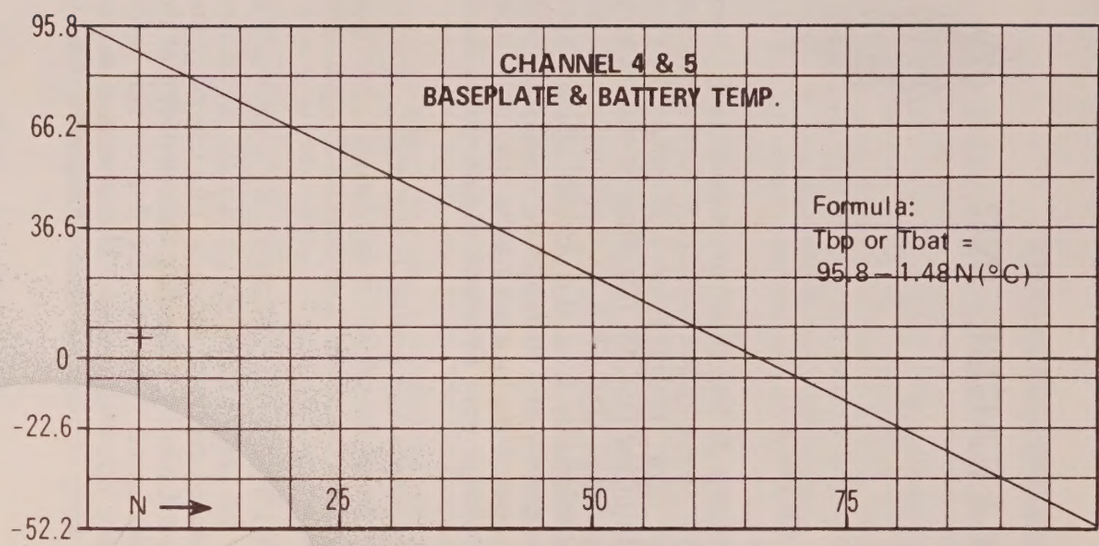
ADDRESS _____
Street

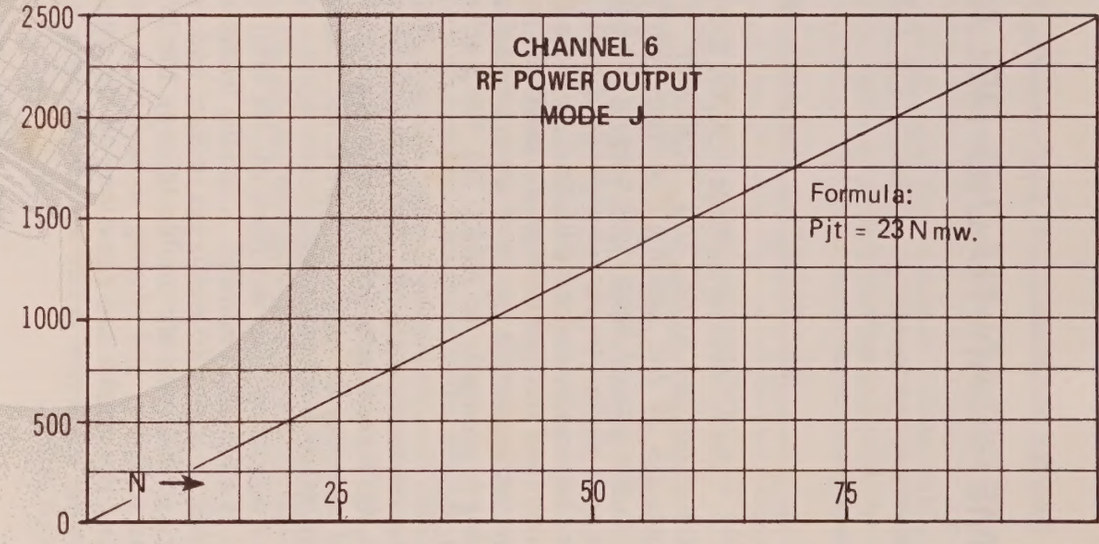
City _____ State _____ Zip _____



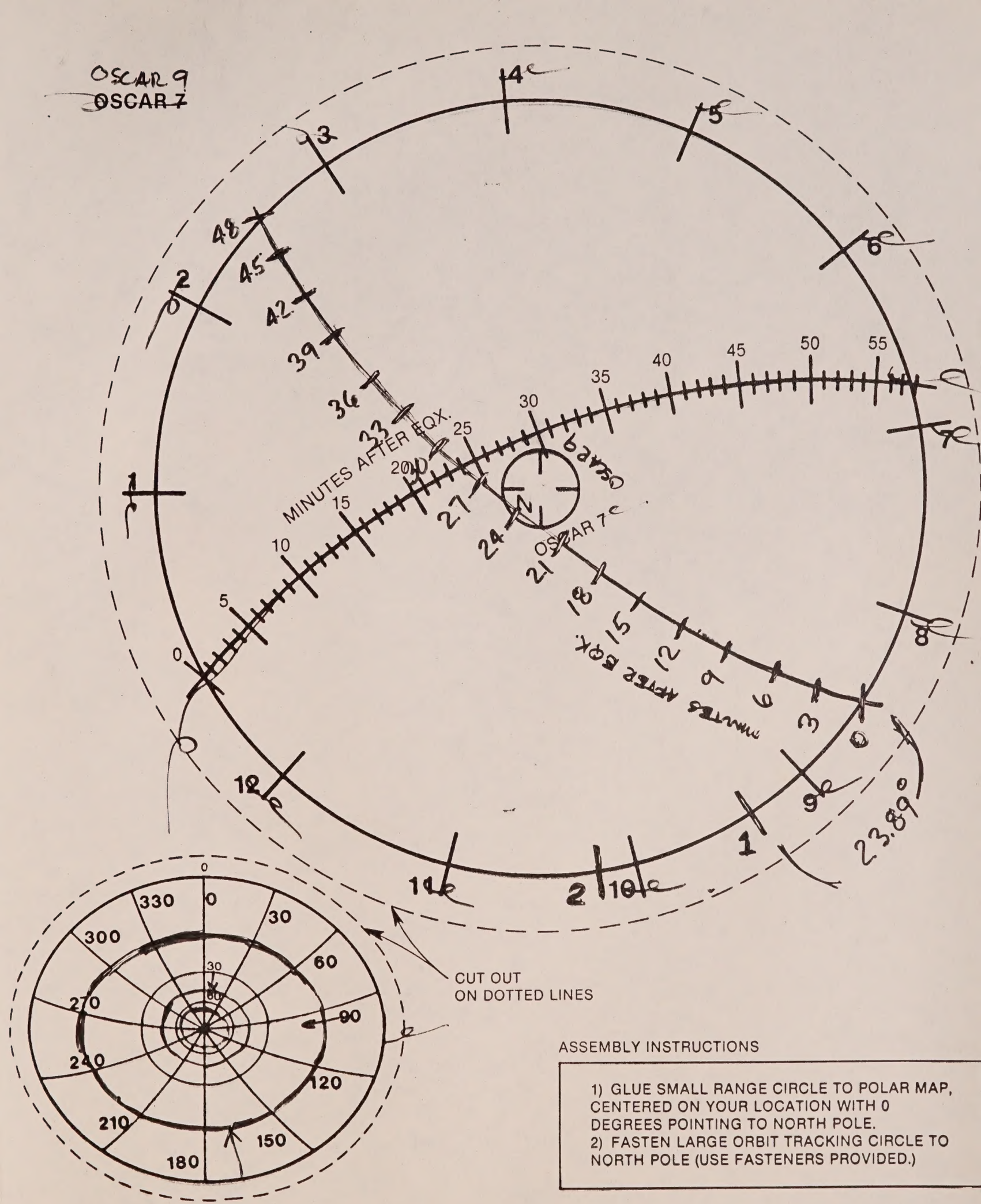








USER NOTES – COMMENTS



ASSEMBLY INSTRUCTIONS

1) GLUE SMALL RANGE CIRCLE TO POLAR MAP, CENTERED ON YOUR LOCATION WITH 0 DEGREES POINTING TO NORTH POLE.
2) FASTEN LARGE ORBIT TRACKING CIRCLE TO NORTH POLE (USE FASTENERS PROVIDED.)